GENETIC ENGINEERING AND ADAPTATION TO CLIMATIC CHANGES: ESTABLISHMENT OF A GENETIC RESOURCES CENTRE FOR IDENTIFYING AND CONSERVING CANDIDATE GENES FOR USE IN THE DEVELOPMENT OF TRANSGENIC PLANTS

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GENETIC ENGINEERING AND ADAPTATION TO CLIMATIC CHANGE: ESTABLISHMENT OF A GENETIC RESOURCES CENTRE FOR IDENTIFYING AND CONSERVING CANDIDATE GENES FOR USE IN THE DEVELOPMENT OF TRANSGENIC PLANTS

1.1 Introduction

International awareness to safeguard global biodiversity has necessitated urgent steps for its conservation and rational or sustainable utilisation at local, regional and global level. This fringing awareness has come a little late but not too late. Disappearance of renewable biological resources from their centres of diversity has been at alarming rate, thanks to over-exploitation of tropical forests and marine ecosystems. There is a vast amount of information available on indigenous species which need to be utilised and harnessed for human welfare, both in the developed and developing counties. Moreover, there is no action plan for conservation and utilisation of biological diversity and genetic resources. The preservation as well as ownership of biodiversity and genetic resources has thus become very important. Therefore, it has become apparent to build safe regional centers in homelands of species; for preservation of vanishing biomaterials. At the same time, the importance of physical and cultural environment cannot be ignored for keeping the genetic diversity intact. The establishment of genetic resources centres for these efforts has been one of the major thrust of this project which would eventually serve as building of "field gene banks" (using in situ technologies) and seed gene banks (using ex-situ technologies).

1.2 Plan of work

The work initiated during 1990-91 under a project titled `Genetic Engineering and adaptation to climate change : Establishment of a genetic resources centre for identifying and conserving candidate genes for use in the development of transgeneic plants" sponsored by the Department of Biotechnology of the Government of India was continued with the cooperation and assisstance of the Tamil Nadu State Forest Department. This work will be further developed during 1992-93 along the following lines :

TABLE 1: GUIDELINES FOR CONSERVATION AND MANAGEMENT OF MANGROVE ECOSYSTEMS

Project Component	Main Activities		
1. Conservation	Work Done	Plan for 1992-93	Future Plan
	*Taxonomic and ecological survey of Pichavaram mangrove forest zonation studies)	*Mapping of Pichavaram mangrove forest including forest inventory (study of associated flora, fauna, phyto-sociological studies of vegetation, phenology, population dynamics of the faunal elements etc.)	*Establishment of two more link centres at National Level
	*Identification of suitable site for establishing mangrove genetic resources centre	*Consolidation of genetic material (mangrove germplasm at Pichavaram and also at link centres	
	*Collection of genetic material mangrove germplasm)	*Survey of Tamil Nadu coast for identification of sites for conservation	
	*Identification of two sites for establishment of link centres of mangrove genetic resources (at National Level)		

Project Component	Main Activities		
2.Restoration			
	*Standardisation of propagation methods for mangroves by vegetative propagation	*Standardisation of micropropagation techniques for mangroves	*Activity to be expanded at larger scale to be monitored by Department of Forest, Government of Tamil Nadu
	*Identification of sites for restoration /eco redevelopment studies	*Large scale plantations	
	*Nursery experiments		*To undertake eco-redevelopment work in the conservation sites identified based on National and State level surveys with support from state forest departments
	*Standardisation of plantation techniques		
	*Pilot scale plantations		

Project Component	Main Activities		
3.Evaluation	*Overall survey of Indian coastline for preparation of state of art on on mangroves	*Preparation of seed orchard of plus material evaluation	*Isolation of candidate genes responsible for sea water intrusion and salt water tolerance
	*Identification of genetic material of plus trees		
	*Select species for the study of variation at intra-specific level	*Evaluation of different mangrove species on (a) their ability to survive in different environmental conditions, and (b) physiological basis	
4.Classification			
	*Study of morphological aspects of classification of mangrove species	*Study of different aspects of classification such as cytogenetical, genetical, biochemical and molecular classification	
	*Identifying superior genetopes in mangrove species.	*Standardisation of techniques for RFLP and RAPD work to study intra and inter-specific variation in mangrove	*Standardising and evolving techniques for multivate analysis for mangrove species

Project Component	Main Activities		
	*Standardisation of software mechanism for the development of data bases, such as (a) mangrove bibliographic data base (b) mangrove experts data base	*To undertake population genetic studies	*Development of other data bases, e.g., mangrove genetic variability data base, socio-economic data base, resources inventory data base and Audio-visuals data base.
5.Utilisation	*Initiation of socio economic surveys in areas near mangrove forests of Pichavaram	*Preparation of eco-matrix based on the principles of socio-economics, e.g., ecological security, economic efficiency and social equity	*Identification genes of for recombinant DNA experiments
	*Preparation of socio-demographic profile and to study human impact on mangroves for better understanding of man-mangrove interaction	*Developing 'Sustainable Livelihood Security Index' (SLSI)	*Standardisation of concept of transgenic plan
		*Testing superior genotypes (hybrids) in other locations	
		*Identifications of seeding markers for heterosis and better performance	
		*Growth characterisation for assessing adult plant performance	

Project Component	Main Activities		
6. Education	*Preparation of - documents related to public awareness and collection of material for exhibition on mangrove ecosystems	*Preparation of exhibits, slides for display and brochures highlighting mangroves of the world and their importance *Public awareness by campaigns involving schools, colleges and universities.	*Preparation of documentary on mangroves

2. CONSERVATION

CONSERVATION

2.1 Introduction

In the earlier report, a detailed account on mangroves of India has been given. Ministry of Environment and Forests, Government of India has already identified fifteen specific mangrove areas for protection. They are - North Andaman and Nicobar (Andaman and Nicobar group of Islands), Sunderbans (West Bengal), Bhitar Kanika and Mahanadi delta (Orissa), Coringa, Krishna estuary and Godavari delta (Andhra Pradesh), Pichavaram and Point Calimere (Tamil Nadu), Vembanad (Kerala), Coondapur (Karnataka), Chorao island (Goa), Achra (Maharashtra) and Gulf of Kutchh (Gujarat). The Government, with the help of different research institutions, has already initiated environmental and socio-economic research in addition to scientific and applied research on flora, fauna and productivity of these mangrove areas.

With a view to prevent further destruction of mangrove forests, for sustained improvement and utilisation of mangrove forest genetic resources, and to conserve and enhance biological diversity in mangrove ecosystems, it was felt that an integrated approach for the preparation of a `Global strategy' is required. The collection and preservation of mangrove genetic resources is the first step towards this end.

2.2 Establishment of mangrove genetic resources centre

Work was initiated to establish mangrove genetic resources centre for adaptation to sea level rise. An area of about 50 ha of land under mangroves was kindly made available by the Department of Forests, Government of Tamil Nadu, in the mangrove forest of Pichavaram, which is located 240 km south of Madras. Out of 1400 ha of land under

mangroves in Pichavarm, this area was selected for *in situ* conservation based on the criteria discussed in the earlier report. In addition to this, a small area within this region was demarcated for consolidation of genetic material collected from different parts of the country.

A nursery was established for this purpose, and the following species are collected from different parts of the country.

Place	Names of Species collected
1. Maharashtra (Ratnagiri, Sindhudurg)	*Rhizophora mucronata*, *Rhizophora apiculata*, *Bruguiera gymnorhiza*, *Ceriops tagal*
2. Goa	*Kandelia candel*, *Porteresia coarctata*
3. West Bengal	*Heritiera fomes*
4. Orissa (Bhitar kanika)	Xylocarpus granatum, X. mekongesis, *Xylocarpus gangetious*
5. Andaman & Nicobar islands	*Rhizophora mucronata*, *Rhizophora apiculata*, *Xylocarpus granatum*, *Bruguiera gymnorrhiza*

In addition to the above-mentioned species, local mangroves species of Pichavaram are also being collected. The success of these species in this type of environmental condition is critically monitored and the data on their performance are being collected.

Some of these species will be planted in the mangrove forest of Pichavaram during the rainy season of 1992 and their ability to survive in different environmental conditions will also be tested.

2.2.1 Establishing link centres of mangrove genetic resources centres

In order to conserve a representative sample of genetic diversity in all the mangrove species in India, the need to establish link centres at the national level was felt. Ministry of Environment and Forests, Government of India, nominated four sites for consideration for international network and a team of four experts visited these sites to explore the possibility of establishing such centres. Criteria of selection was prepared and based on this, the sites were evaluated. It was important to recognise that the selected sites are not intended to serve as national parks, but as genetic gardens to conserve and enhance genetic diversity in mangroves. The criteria of selection are as follows :

a. Anthropogenic factors : Population density in neighbouring areas, proximity to population centres and industries, and conservation awareness,
b. Land size : A minimum of 100 hectares,
c. Land tenure : Ownership of land,
d. Accessibility of site,
e. Human resources : Training and motivation of staff and commitment of national government,
f. Reconnaissance and monitoring facilities : Equipment, proximity, and preparedness of staff,
g. Socio-political factors,
h. Economic factors : Long-term funding and degree of priority,
i. Genetic factors : Migration and gene flow, introgression, natural outcrossing, competition and selection, and polymorphism,
j. Ecological factors : Local flora and fauna, species richness and eveness, and bioindicators of biodiversity and pollution levels,
k. Environmental features : Topography and environmental variables, level of environmental degradation, micro-environ-

mental heterogeneity, frequency and intensity of cyclones, typhoons and other natural hazards,

l. Physiological factors : Overall forest health, individual species health, nutritional cycle, and estuarine characteristics, and

m. Potential for both, in situ and ex situ conservation of biodiversity, seasonal fluctuations in environmental conditions, environmental extremes, and plant population density.

2.2.1.1 Method of Evaluation

The evaluation of sites was done largely according to the 10 criteria listed below.

1. Genetic aspects: Introgression, potential for ex situ preservation, visual polymorphism.
2. Biological aspects: Species richness, nutritional level, environmental degradation.
3. Utilisation level: Human use and exploitation.
4. Neighbouring flora and fauna: Associated ecosystem.
5. State of forest: Level of degradation.
6. Accessibility: Distance from main population centres, transportation facilities.
7. Personnel: Training, turn-over rate etc.
8. Anthropogenic factors: Threats, level of dependence etc.
9. Socio-political factors: National commitment, land tenure and public awareness.
10. Land Size: Area available at the proposed site for GRCC.

Respective area of expertise were given due consideration during final discussions and scoring. For each criterion, an ordinal score between 1 and 9 was assigned to each site, where 1 = best or most desirable and 9 = worst of least desirbale. Scores given independently by a team of four experts who

evaluated this sites these sites, were averaged to determine the final score of a site for each criterion.

Out of the proposed sites, two sites - one on the west coast (Chorao island, Goa) and the other on the east coast (Bhitar kanika, Orissa) are selected for establishing link centres. Information on these sites is given below.

TABLE 2. MANGROVES OBSERVED AT THREE SITES IN INDIA

	Chorao Goa	Pichavaram Tamilnadu	Bhitarkanika Orissa	Total
Aegiceras corniculatum	X	X	X	X
Lumnitzera racemosa		X	X	X
Sonneratia alba	X			X
S. apetala			X	X
S. caseolaris			X	X
Bruguiera cylindrica	X	X	X	X
B. sexangula			X	X
Ceriops decandra		X		X
C. tagal		X		X
Kandelia candel	X		X	X
Rhizophora apiculata	X	X		X
R. mucronata (India)	X	X	X	X
R. X sp. (hybrid form)		X		X
Excoecaria agallocha	X	X	X	X
Xylocarpus granatum			X	X
X. mekongensis				X
X. gangeticus			X	X
A. marina var. marina	X	X		X
A. officinalis	X	X	X	X
Acanthus ilicifolius	X	X	X	X
Cynometra iripa			X	X
Heritiera fomes			X	X
Brownlowia tersa			X	X
Total	10	12	17	24

TABLE 3: MANGROVE ASSOCIATES OBSERVED DURING SITE VISITS IN INDIA

Species	SITES Goa	Pichavaram	Bhitarkanika
Aeluropus lagopoides	X	X	X
Amoora cuculata			X
Arthrocnemum indicum		X	
Caesalpinia nuga			X
Cerbera manghas			X
Clerodendrum inerme	X	X	X
Cyperus ferruginea	X	X	X
Dalbergia spinosa			X
Derris trifoliatia	X	X	X
Derris uliginosa			X
Fimbristylis ferruginea			X
Instia bijuga			X
Myriostachya wightiana			X
Phoenix paludosa			X
Pongamia pinnata			X
Porteresia coarctata	X		X
Salvadora persica	X	X	X
Salicornia brachiata		X	X
Sesuvium portulacastrum	X	X	X
Suaeda maritima		X	X
Suaeda monoeica		X	
Tamarix gallica			X

TABLE 4. SUMMARY OF EVALUATION OF THREE INDIAN SITES*

Criterion	Site Chorao Goa	Pichavaram Tamil Nadu	Bhitarkanika Orissa
Genetic aspects	5	4	1
Ecological aspects	4	5	2
Utilisation level	5	5	2
Neighbouring flora/ fauna	4	5	4
State of Forest	5	5	2
Accessibility	2	4	6
Personnel	2	3	2
Anthropogenic factors	5	4	2
Socio-political factors	2	4	2
Land size	3	4	2
Overall **	3.7	4.3	2.5

* 1 = best or most desirable, 9 = worst or least desirable.
** Based on equal weight for all criteria.

1. Chorao island, Goa : The land is owned and controlled by the Government of Goa, where a totally protected mangrove area of 160 ha is available. It harbours a good mangrove flora, comprising about 13 mangrove species and 7 species of mangrove associates. There are no major anthropogenic threats. The National Institute of Oceanography, Goa has a major programme and strong commitment to research and development of mangrove ecosystems of this island.

2. Bhitar kanika, Orissa : The site is within a protected forest owned and controlled by the Government of Orissa. About 40 sq.km of buffer zone is available around the proposed site. Being included in a wild life sanctuary and reserve forest, the proposed site is well protected and virtually free from human interference. Genus Xylocarpus shows remarkable variation, representing three species.

Pichavaram will serve as a co-ordinating centre for collection and consolidation of mangrove genetic material, where as the link centres will take care of the genetic wealth at local level.

2.3 About mangroves of Pichavaram

Despite the availability of large number of descriptions, mangrove areas of Pichavaram still remain to be assessed properly. The total forest area at Pichavaram is getting reduced year after year because of human interference. There is an urgent need for conservation and protection. The work undertaken under this head includes the following aspects :

1. Mapping, survey of flora (taxonomic and ecological), and fauna ;
2. Forest inventory studies ;
3. Environmental inventory (water and sediments) ; and
4. Studies on productivity and biomass.

2.3.1 Mapping

Pichavaram mangrove forest located in the Vellar-Coleroon estuarine complex, consists of many islands separated by intricate waterways. A total number of 51 islands have been ascertained and the studies on 'forest inventory' are underway. With the help of aerial photographs available in National Remote Sensing Institute, Hyderabad and Institute of Remote Sensing, Anna University, Madras, a detailed map depicting the extent of vegetation and also that of waterbodies will be prepared which would provide a clear picture on the loss of vegetation in recent years.

2.3.2 Environmental inventory

The fundamental impacts of climatic factors on mangrove vegetation are many and they can be summarised as follows:

1. Rainfall occurring in catchment areas is more determining than open tidal forests;

2. Local salinities are controlled by rainfall and hence interference in the evaporation rate and thermal condition is observed due to changes in rainfall patterns;

3. A change in number of mangrove species observed which decreases with increase in mean annual thermic amplitude;

4. Increased salinity of water and sediments leads to decrease in number of mangrove woody species and also in standing phytomass.

Data on hydrological and meteorological parameters is being collected. This will help in knowing the impact of climatic

factors and also role of soil properties on the distribution and productivity of these species.

2.3.2.1 Soil studies

In spite of decades of research on mangrove soils, until now, it remains a mystery when one tries to establish simple and comprehensive relationships between distribution of mangrove plants or productivity and local soil properties. Studies were initiated for characterising each major mangrove zone, through its soil properties. Some of the results give an idea about the complexity of mangrove ecology even if we consider only its edaphic component.

Six profiles belonging to a sequence running from mangroves to the island bare flats were observed and sampled. The details of sampling spots are as follows :

Sample No.	Names of species observed in that area	Description of soil
1.	Pure Rhizophora mucronata Stands	Loose soil, dark grey coloured clayey in nature
2.	Rhizophora mucronata Avicennia marina with few Aegiceras corniculatum	Clayey in nature highly solid, fibrous
3	Avicennia marina, Avicennia officinalis, Ceriops tagal Excoecaria agallocha	Reddish brown, clayey, compact
4.	Sueada maritima, Sesuvium portulacastrum and few Avicennia marina	Very hard, grey
5.	Totally cleared area (barren) with dead trunks of Avicennia species	Humid, fibrous carpet of salt, formed due to stagnation of water
6.	Barren areas	Very dry soil, sandy in nature with encrustations of salt.

All the above areas except the first one were marked dry and firm and due to inconsistent rains which lead to low amplitude of tides, the soil and had become compact in nature.

2.3.2.1.1 Chemical characteristics of soils

The most conspicuous feature of soils of Pichavaram is their high salinity. The results of some chemical characters of soils have been summarised in Table 5.

TABLE 5: ANALYTICAL DATA ON SOILS OF PICHAVARAM

Sample	Depth (cm)	pH	E.C. mS/cm	Ca	Mg	K	Na	Cl
				mg/100 gm dry soil				
1.	0-30	7.1	32.2	4.88	11.00	1.62	47.0	60.2
	30-60	7.6	33.7	2.30	9.60	1.28	51.0	65.7
	60-90	7.9	21.8	1.06	5.88	1.00	32.0	43.4
2.	0-30	7.3	33.3	5.20	16.00	1.90	57.0	63.6
	30-60	7.9	28.1	2.80	10.70	1.56	52.7	54.6
	60-90	8.0	25.0	1.08	6.22	1.09	38.0	46.2
3.	0-30	7.4	37.8	5.42	14.80	1.58	70.0	81.6
	30-60	6.8	35.2	5.90	14.60	1.52	56.0	72.8
	60-90	7.4	34.8	5.20	12.30	1.92	48.8	57.4
4.	0-30	6.9	66.7	3.18	12.20	0.90	48.2	113.5
	30-60	8.1	30.0	2.96	9.00	0.84	36.0	58.7
	60-90	7.9	27.6	2.90	8.88	0.76	45.2	51.6
5.	0-30	7.6	81.8	4.50	20.60	1.84	89.0	146.3
	30-60	7.6	54.2	7.60	30.00	2.20	117.0	112.0
	60-90	7.9	68.9	9.30	36.60	3.00	130.0	157.6
6.	0-30	6.3	109.7	4.20	16.80	1.18	83.5	118.2
	30-60	6.1	53.4	6.00	23.00	1.40	88.8	104.9
	60-90	6.0	63.0	7.20	26.20	1.65	115.5	122.3

Extract 1/2

It can be seen from the above table that there is a sudden change in the salinity of barren areas which is almost twice that of areas occupied by mangroves. All profiles when compared, were highly saline and in general the salinity of surface horizons was found to be higher than that of deeper horizons, Moreover, the salinities of some samples have attained values higher than 80 mS/cm. The soils of Pichavaram are thus characterised essentially by a sodium chloride type of salinity, anions being represented by chlorides and cations by sodium and magnesium.

The soil properties of Pichavaram mangrove swamp reveal that mangroves show a complexity of problems related to mangrove ecological processes. A detailed study is underway to understand these processes is underway and it is hoped that a more clearer picture will emerge from it.

2.3.3 Forest Inventory Studies

Like any other plant community, the constituent plants of the mangrove community interact with one another, often in specific or defined ways. Many of these interactions are subtle and little studied.

2.3.3.1 Phytosociological studies

Mangrove forest of pichavaram could be considered as a low forest. To understand the contribution of component species and their quantitative aspects, phytosociological characters of the stands is being studied. For this purpose transects were laid from the seaward to the landward side depending on the intertidal expance of the mangrove vegetation. Similarly, measurements and counts were made with 10 X 10 m quadrats. Quadrats were laid at 10-20m intervals along the right angles to each transect line.

Trees larger than 2.5 cm diameter at base were recorded in each plot for the following:

1. Number of species of individuals,
2. Height of canopy, and
3. Basal area

All the 51 islands of Pichavaram comprising the entire mangrove forest area will be covered shortly and data will be completed for frequency, density and dominance of different mangrove species. Complexity Index, Importance Value Index (IVI) and Shannon Index (H) for species diversity will be worked out for expressing dominance and ecological success of each species, and also the diversity of species. These studies will be completed by December 1992.

2.3.3.2 Phenology

The purpose of the phenological data collection is to find out the extent of linkage between vegetative and reproductive phenologies, cause of such linkages and the relationship between the behaviour of these plants with certain environmental variables. Studies on vegetative and reproductive phenologies are underway. To support these studies data on leading phenology and leaf longevity are also being collected.

2.3.3.3 Productivity and biomass studies

High productivity of mangroves is generally expressed in terms of litter production. Litter traps have been laid in the mangrove forest of Pichavaram to collect various litter fractions. Litter fall data will be useful in the compilation of detailed sequence of various stages of maturation, starting from leaf appearance to seedling production. Biomass studies include the estimation of above-ground biomass which will be expressed as Kg ha^{-1} for different stands of mangroves.

RESTORATION

3.1 Introduction

The mangrove ecosystem though open, is quite complex, being composed of various inter-related elements in the land-sea interphase zone. The mangroves are known to keep the shoreline intact against tidal currents by preventing soil erosion. In view of the ecological and socio-economic importance of these plants, their restoration has become increasingly important, especially in recent years when land cover of the earth is rapidly on the wane.

Development of suitable forestry methods for propagation and artificial regeneration of mangroves have been prompted by the demand for the economically valuable mangroves; however, not much has been achieved in this respect. The work on experimental plantation of mangroves undertaken at Pichavaram has been described in the following pages. In the present studies, emphasis has been placed on the germination and growth of some mangrove species in nursery conditions and also in field on experimental basis. The studies reported here are broadly classifiable into two categories:-

1. Nursery experiments, and
2. Pilot plantations of mangroves.

3.2 Nursery experiments:

A mangrove nursery was established in Killai, about 2 km away from Pichavaram mangrove forest, to evaluate the performance of mangroves under fresh water conditions. The need to raise mangrove nursery was based on the consideration that in nature, the propagules of mangroves are available only in certain parts of the year. Therefore, it would be possible

to raise propagules into saplings by growing them in the nursery and planting them the next year, subject to planting stock.

Laboratory investigation of seed germination indicates that seeds of most of the halophytic species reach their maximum germination in distilled water (Seneca, 1969; Dietert and Shontz, 1978). Taking several factors into consideration, Rhizophora mucronata was selected for this type of study and mature propagules of this species were sown in polybags filled with non-saline sandy soil ior garden loam with farm yard manure (FYM) in proportion of 3:1. They were irrigated with fresh water. No amendment in water or soil was used. However, using farm yard manure as a source for improving the condition of soil was considered to serve as a relative control.

To begin with, around 500 propagules of Rhizophora mucronata were sown. Data on germination and growth in terms of stem elongation, number of leaves and nodes, were collected during the year 1991-92. Growth parameters also included length and diameter of internodes, number of lateral branches, etc. Leaf area was estimated only for selected individuals.

Data on monthly survival percentage of Rhizophora mucronata under fresh water irrigation in polythene bags are presented in Table 6.

TABLE 6: PERCENTAGE SURVIVAL OF RHIZOPHORA MUCRONATA UNDER FRESH WATER CONDITIONS
(No. of propagules sown = 485)

Month	No.of propagules survived	Percentage survival
July	360	74.5
August	292	60.2
September	280	57.7
October	272	56.0
November	259	52.9
December	243	50.1
January	226	46.5
February	220	45.3
March	211	43.5

Similarly, morphometric data of Rhizophora propagules were collected on a monthly basis, the details are highlighted in Table 7.

The data collected from the above mentioned tables will be compared with the performance of propagules growing in natural conditions. Similarly, a comparative account of such performance will be taken for different mangrove species which will be collected during this year.

3.3 Pilot Plantations:

A general approach for eco-restoration effort was worked out on the basis of the assessment of local factors. The observations were based on the following point:

3.3.1 Area Selection:

The first step was to identify areas where pilot scale mangrove planting effort could be tried out. In this context, the initial survey of the Pichavaram mangrove forest was very helpful. There are many areas in this forest, which are totally destroyed either because of excessive cutting or over-grazing, but they are still capable of supporting mangroves, if brought under plantations. Forest Department of the Government of Tamil Nadu has been involved in this type of effort during last couple of years and the work has been done in most of the "upper shore" areas of the intertidal zones. It was therefore decided to initiate the work from the " lower shore " region in this mangrove forest.

Based on initial surveys, five such regions were identified in the mangrove forest of Pichavaram. Though all the five regions were supposed to have similar type of substratum due to their position in the intertidal zone, they

TABLE 7 : MORPHOMETRIC DATA (MEAN +S.E.) OF SEEDLINGS OF RHIZOPHORA MUCRONATA GROWN IN FRESH WATER CONDITIONS AT KILLAI NEAR PICHAVARAM

Growth Parameter	Months								
	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1. Net growth in height (cm)	36.6+0.37	37.2+0.40	39.7+0.42	40.9+0.45	41.7+0.46	41.9+0.47	42.3+0.471	42.5+0.475	43.1+0.48
Range	10-57	16.5-56	20-60	20-61.5	13-63	13.4-65	14-62	13-65	14-67
2. No. of internodes/ seedling	0.07+1.36	0.88+4.44	1.61+4.93	1.95+6.78	2.66+7.17	2.79+7.52	3.24+8.73	3.29+8.86	3.31+8.91
Range	0-1	0-2	0-4	0-4	0-6	0-10	0-10	0-10	0-11
3. No. of leaves / seedling	1.20+5.10	2.83+9,91	3.39+0.17	4.38+0.14	5.16+0.15	5.38+0.19	5.87+0.16	6.09+0.17	6.22+0.18
Range	0-3	0-6	0-6	0-8	0-9	0-10	0-12	0-12	0-14
4. Diameter of first internode	0.25+4.97	0.58+2.53	0.82+1.96	0.98+0.32	1.00+0.31	1.01+0.28	1.05+0.23	1.09+0.19	1.12+0.10
Range	0-0.6	0-1.0	0-1.09	0-1.01	0-1.10	0-1.10	0-1.10	0-1.30	0-4.10
5. Mean leaf area/ seedling (cm^2)	-	-	72+0.86	73.5+0.82	74.9+0.79	79.2+0.88	81+0.90	81.2+0.91	83.3+0.93
6. No. of lateral branches/ seedling	-	-	0.87+2.31	0.99+2.29	1.03+2.23	1.41+2.17	1.50+2.08	1.54+1.91	1.63+1.72
Range	-	-							
0-2	0-4	0-4	0-4	0-4	0-5	0-5.2			

differed from each other significantly because of their position in the deltaic region in the forest. The location of these areas was selected in such a way that each of them appeared in a different region, starting from the mouth of the estuary, towards upstream, in deltaic region.

The planting stock tried out was of Rhizophora mucronata, a dominant species from lower shore regions of the intertidal zone and was obtained from the west coast of Maharashtra State through personal visits. Department of Social Forestry, Government of Maharashtra, was the main source for providing a certain quota for plantation. Rhizophora propagules, thus obtained, were used for direct planting in the above mentioned areas in numbers, as given below:

TABLE 8 : TRIAL PLANTATIONS OF RHIZOPHORA RAISED IN PICHAVARAM

Site No.	Name of Site	No.of propagules planted
1	Salangodamunai	299
2	Vadakuttamunai	5054
3	Kottumunai	584
4	Kakkaticharangam	910
5	Banglathittumunai	723
	Total	7570

For experimental plantations, propagules were planted in rows, parellel to the water level, from water-front to landward side. Nearly 1/4th to 1/3rd (but not more) of a propagule was embeded in the soil directly instead of making bores and then planting.

The seedling survival was estimated periodically on a monthly basis. For this purpose, 10 x 10 m quadrats were laid and details such as germination and survival were noted down.

Germination/sprouting of Rhizophora mucronata propagules planted on the mudflats in the lower shore of intertidal region

in all the sites was very promising. Overall germination percentage of Rhizophora seedlings in all the five sites can be observed in the following table.

TABLE 9: PERCENTAGE GERMINATION OF RHIZOPHORA MUCRONATA, SEEDLINGS IN DIFFERENT SITES , 10 MONTHS AFTER SOWING

Name of site	% germinataion	% mortality
1. Salangodamunai	29.60	70.4
2. Vadakuttamunai	63.20	36.80
3. Kottumunai	50.42	49.58
4. Kakkaticharangam	58.29	41.71
5. Banglathittumunai	31.84	68.16

A belt transect taken from seaward to landward side exhibited a good relationship between survival and mortality at all the five sites, which is evident from Figures 1,2,3,4 and 5.

The percentage survival of the propagules will be correlated with the edapho-hydrological conditions, such as underlying soil type, number of inundations and salinity levels of each site. This will help in undertaking large-scale plantations in the forthcoming year which would ensure maximum survival. It is also planned to standardise techniques for plantations of different mangrove and associate species at Pichavaram mangrove forest. For large-scale afforestation work, help will be sought from the Forest Department of Government of Tamil Nadu. Similarly, this type of work will also be undertaken simultaneously in different regions of the State which have already been identified for restoration programmes.

Figure 1 : Row-wise survival of Rhizophora seedlings in Site I

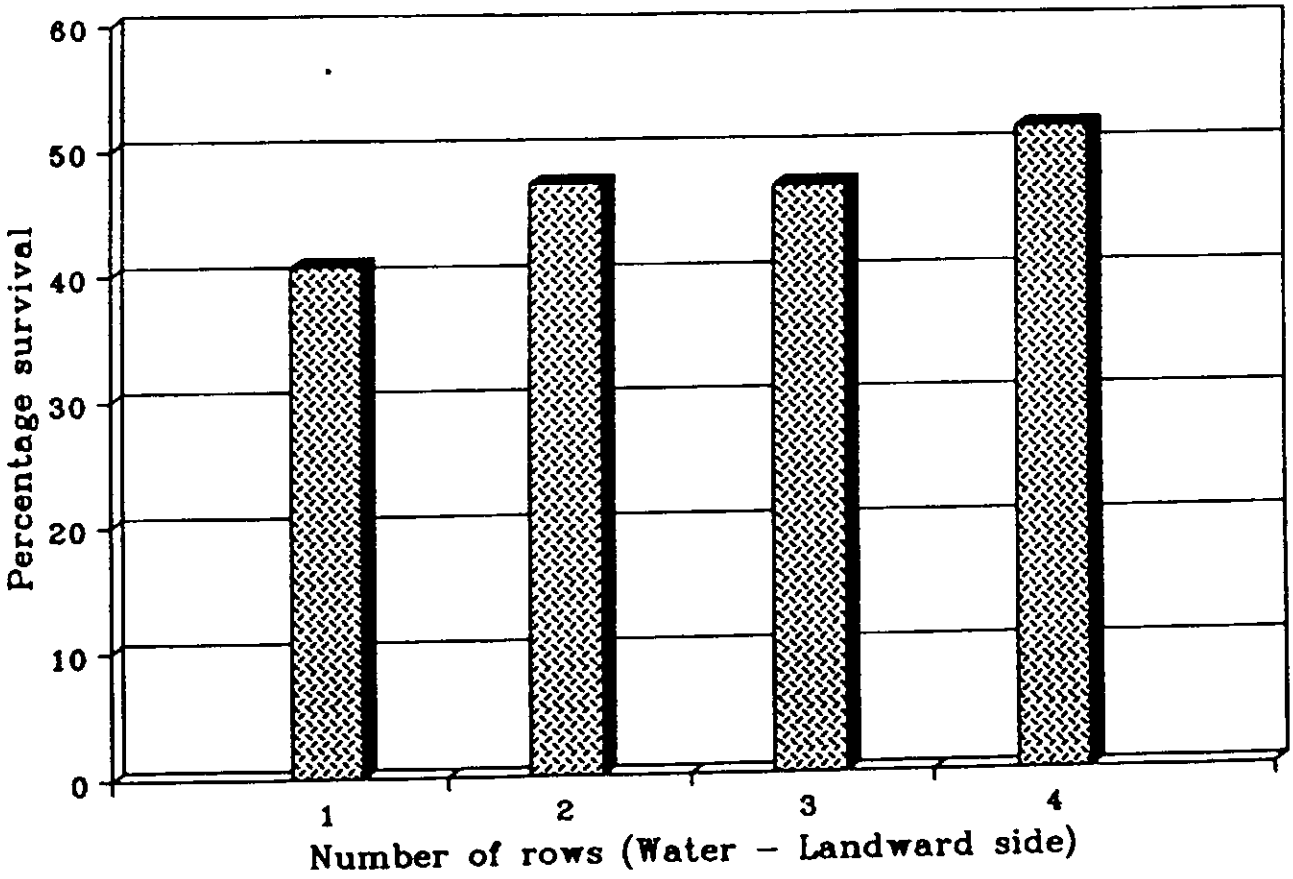


Figure 2 : Row-wise survival of Rhizophora seedlings in Site II

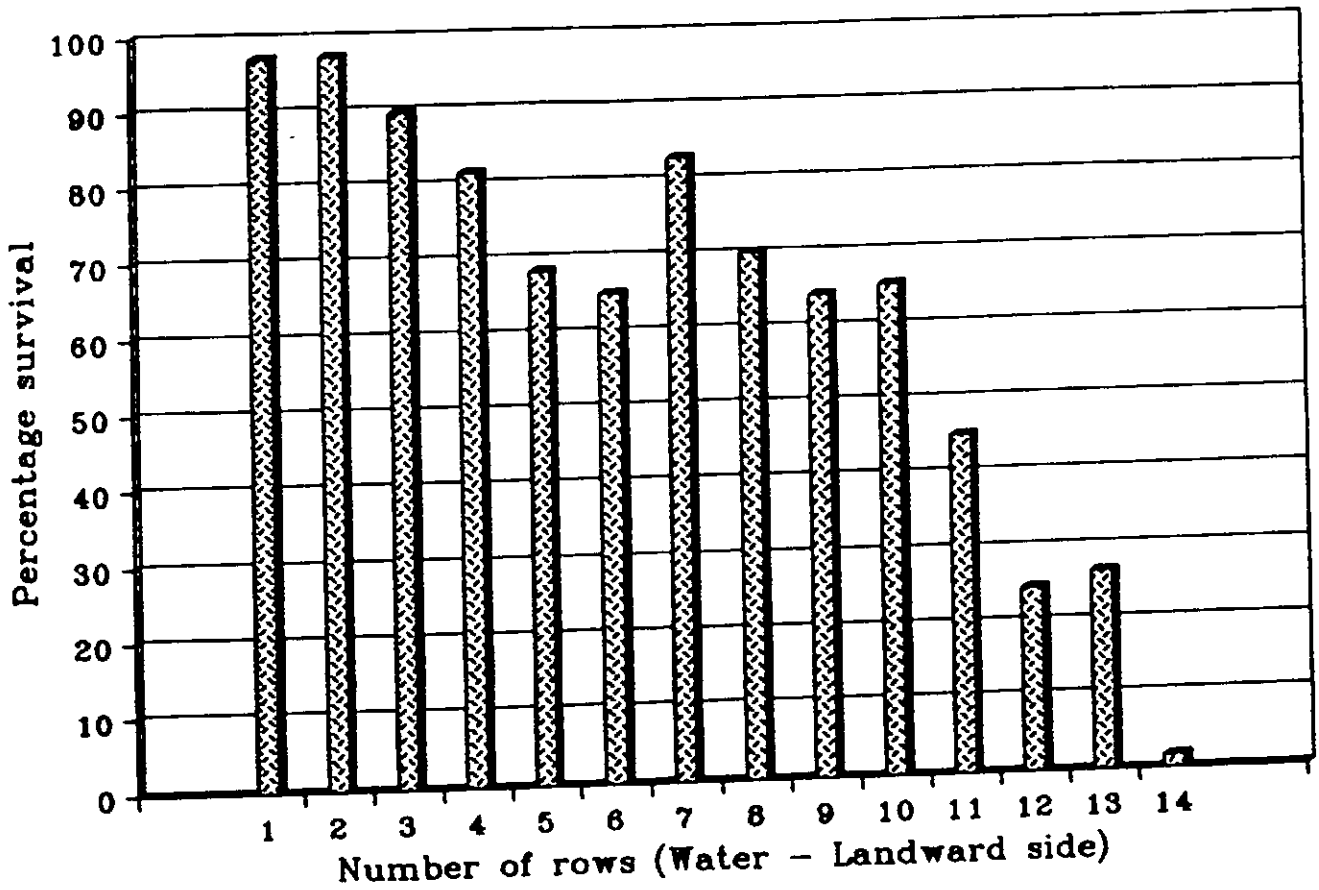


Figure 3 : Row-wise survival of Rhizophora seedlings in Site III

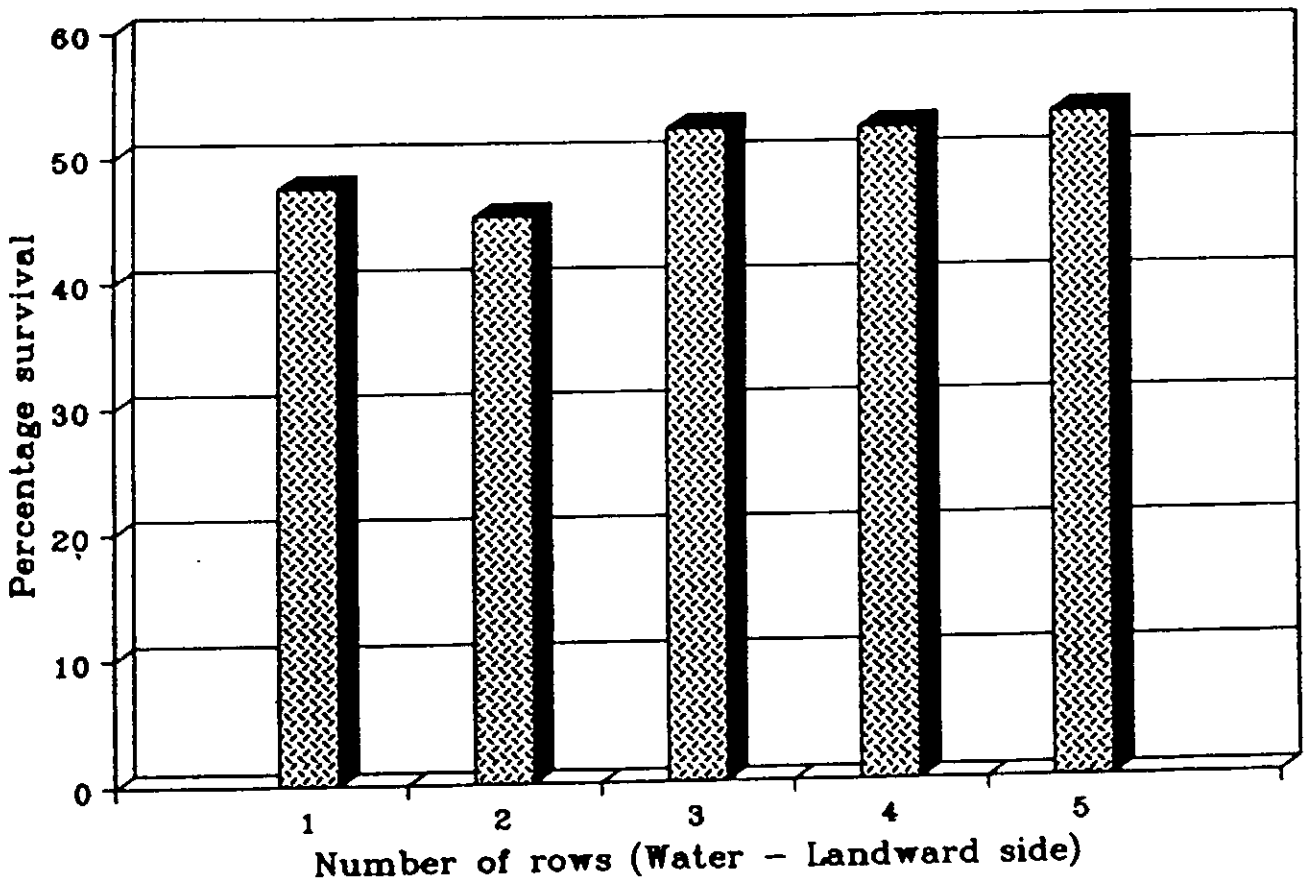


Figure 4 : Row-wise survival of Rhizophora seedlings in Site IV

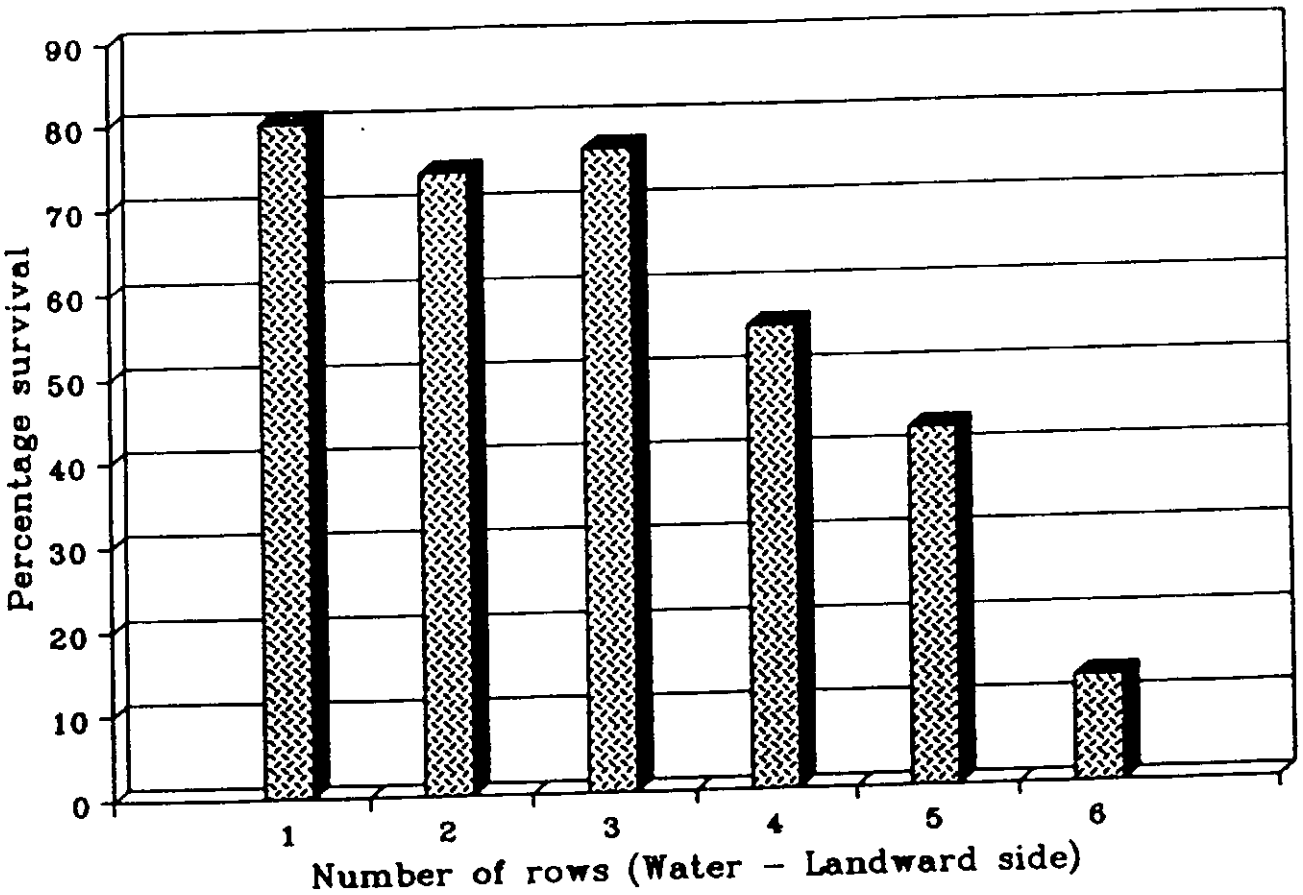
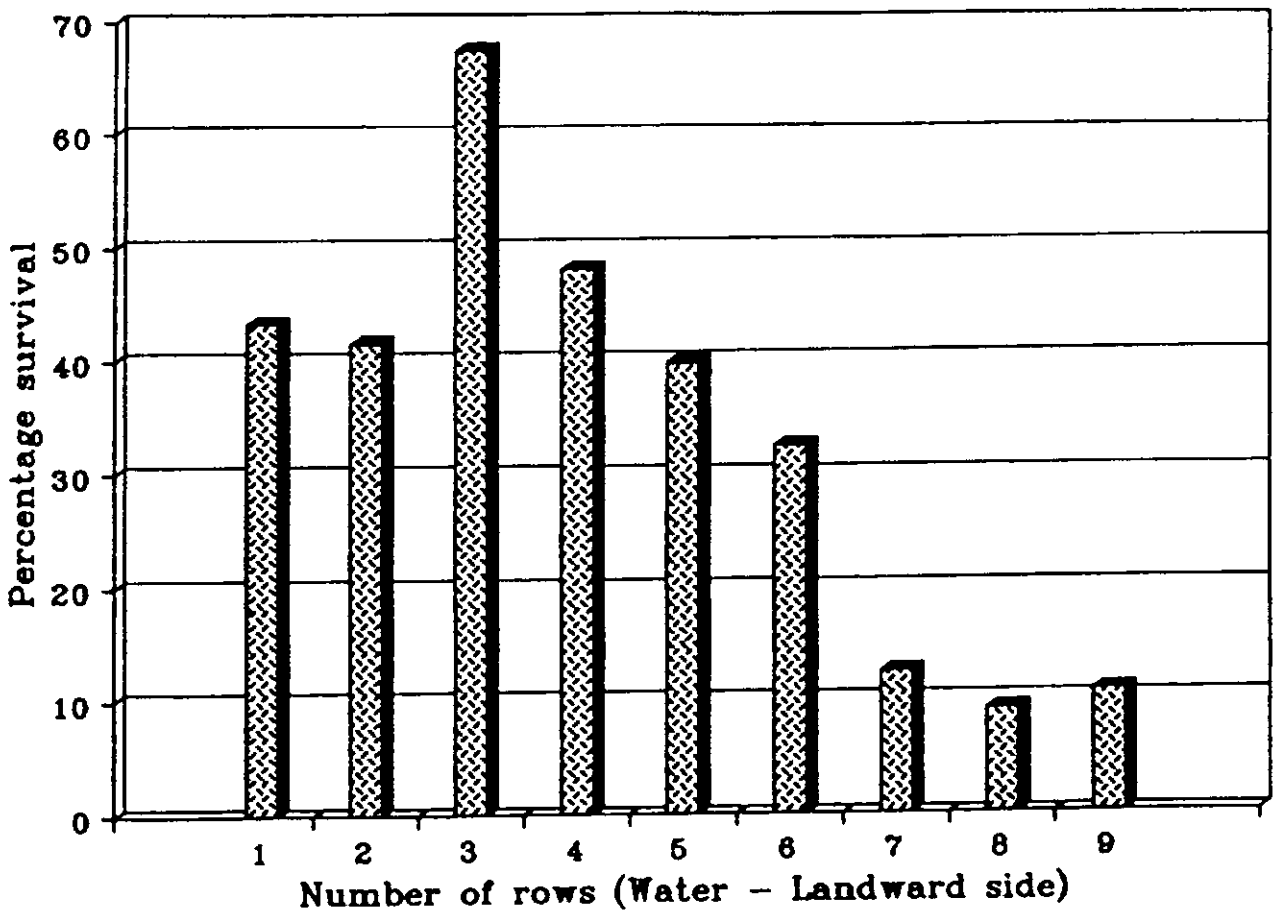


Figure 5 : Row-wise survival of <u>Rhizophora seedlings in Site V</u>



3. EVALUATION

EVALUATION

4.1 Introduction

Mangroves are distributed according to three important scales, namely their coastal range, their location within an estuary and their position along the intertidal profile. Distribution pattern of mangroves in an estuarine region depends on several factors. Influence of freshwater run off and also estuary size is always seen when composition of mangrove floras is observed. In larger estuaries, there is greater range of specialised habitats, and hence the presence of more species as compared to those in smaller estuaries is evident. There is a general trend between genera and distribution, in such a way that genera with greatest number of species consistently occur in greater number of biogeographic regions. In addition to this, there is also isolation at other scales of distribution, notably in the specialisation of particular mangroves for certain habitats.

When mangrove species are classified, the morphological characters of the species are taken into consideration, and have to be re-assessed for their systematic classification. When such classification is based on phenotypic characters, which may vary their response in different locations, it is also useful to explore intra-specific variation so that inter-relationships of those in larger polymorphic genera might be better understood. Rhizophora and Avicennia, the two major species of mangrove ecosystems, are being studied for their botanical systematics or scientific classification. The surveys made so far have also provided interesting information on the distribution of these two as well as other mangrove species, including the location for not only particular estuarine sites, but also for particular section of estuaries. This knowledge will also be used for evaluating

particular distribution patterns of other species mangroves, which depend on several factors. These studies would also lead to better understanding of genetic exchange between populations, which is controlled by climatic and geological conditions.

4.2 Identification of genetic material of plus trees:

Surveys undertaken for identification of plus trees of various species of mangroves in different parts of India has revealed information on location of such "genetically important" material which can be seen from the following table 10.

The species mentioned in table 10 will be collected and will be maintained in suitable locations in Tamil Nadu, to begin with, in Pichavaram mangrove forest. Evaluation of these species will be done on physiological basis and also on their ability to survive in different environmental conditions.

4. CLASSIFICATION

CLASSIFICATION

5.1 Introduction

It is common these days to have come across ill-defined morphological characters of tropical plants. Mangroves are no exception to this. Considering the limited number of these unique plants and the extent of the variation of species level, it is important to have sorted out these constraints, and therefore, it would be useful to identify genetic differences thereby removing the doubts and subjectivity surrounding the diagnostic characters in the systematics of these plants. There are two techniques.

Conventional genetic studies are difficult in mangroves and many forest tree species. In view of the difficulties and delay in conventional genetic analysis it was proposed to standardise molecular methods of genetic analysis using the molecular variation in DNA. The method is described as follows :

5.2 Use of RAPD analysis in the study of Genetic variability in mangrove species

Base pair changes in DNA can alter sequences that are recognised by restriction enzymes, abolishing sites or creating new sites for particular enzymes. Deletions or transpositions of large elements will make simultaneous changes in the restriction patterns of a number of enzymes. As a result, a given restriction enzyme will not always cleave a given DNA molecule at the same position in two individuals. Consequently, fragments of two different lengths will be formed when the DNA of the two individuals are digested. The un-equal sized fragments will travel at different rates through the gel, and the band formed, following hybridization and autoradiography , will be located at different locations

on the Southern blot. The polymorphisms could be scored on such autoradiographs.

5.3 Random Amplified Polymorphic DNA (RAPD)

The polymorphism assays based on the Polymerase Chain Reaction (PCR) are useful in detecting the variations much more rapidly. But there is a distinct PCR process, based on the amplification of genomic DNA with single primers of arbitrary nucleotide sequences. These primers reveal better polymorphisms and are therefore used as markers. They are called the Random Amplified Polymorphic DNA (RAPD). Use of RAPDs have several advantages over other markers as : (i) a universal set of primers can be used for genomic analysis in a wide variety of species, (ii) no preliminary work, in the form of isolation of cloned DNA probes, preparation of filters for hybridisation, or nucleotide sequencing are necessary, (iii) each RAPD marker is the equivalent of a Sequence Tagged Site, and (iv) the entire process of finding the polymorphism can be automated.

The work based on these lines has been carried out which has helped to understand the inter- and intra specific variability in mangrove species. Details are given as follows:

5.4 Use of RFLP Analysis in the Study of Genetic Variability in mangrove species

Work on RFLP analysis in mangrove species was initiated in March 1991 with the facility kindly provided by the Anna and Madras Universities (Department of Biotechnology and the Centre for Advanced Studies in Botany, respectively) and the Southern Petrochemical Industries Corporation (SPIC) Science Foundation. In addition to this help was also taken from International Centre for Genetic Engineering and Biotechnology

(ICGEB), New Delhi for the further studies on Random Amplication of Polymorphic DNA (RAPD) analysis.

5.5 Studying genetic diversity and phylogenetic relationship application of Molecular markers

Recent techniques in molecular biology provide high resolution of genetic differences, both at intra and inter-specific levels. The usefulness of restriction fragment length polymorphism (RFLP) for studying the genetic diversity and phylogenetic relationship has been shown by different authors in recent years. However, another recently developed technique called random amplification of polymorphic DNA (RAPD) is being found to be less expensive and faster than the conventional RFLP.

The present investigation to understand this inter - and intra-specific variability and phylogenetic relationships in different species of Rhizophora collected from Pichavaram (Tamil Nadu) and Andaman Islands is based on the RAPD markers.

5.5.1 Isolation of DNA

Isolation of DNA from Rhizophora species becomes difficult due to the presence of mucilage and other secondary products, which prevent the lysis of the nuclear membrane. An isolation technique from the young leaves of Rhizophora has been standardised. The leaves were powdered well in liquid nitrogen and treated with the buffer containing Triton X - 100 at 65 C for 30 minutes for lysing the cell membrane and centrifusing at low rpm to spinning down the nucleus. Repeated treatment with the buffer and centrifuging helped to remove the major part of the cytoplasmic contents. The nucleus thus separated, was lysed with suitable buffer and the DNA was isolated for the RAPD work.

5.5.2 Random amplification of Polymorphic DNA (RAPD)

This part of the work has been carried out at ICGEB, New Delhi species like Rhizophora apiculata, R. mucronata and a hybrid form of Rhizophora colected from Pichavaram, and R. apiculata, R. munarota and R. stylosa collected from Andaman Islands were used for the study. Twenty four random primers obtained from 'operon' were studied. Polymerase chain reaction (PCR) for the amplification was carried out in a thermocycler. The PCR products were resolved in 1.2% agarose gel containing ethydium bromide and the gel was photographed using Polaroid films.

The banding pattern showed distinct variations a) between species and b) within and between populations of the same species. The statistical analysis of the data and further work on these lines is in progress.

5.6 Designing a mangrove ecosystem information systems (MEIS)

The main purpose of creating this information system is to develop a system with global, regional and national components. At the global level, the data base management system will have to be developed for the dissemination of information on the available mangrove genetic resources. At the regional level, there will be regional genetic resources centres linked with genetic enhancement centres. Finally, at the national level, a policy for the conservation of coastal ecosystems in general, and mangrove ecosystems in particular, will be formulated. In addition to this, research work on genetics, cytogenetics, taxonomy and physiology of mangrove and other associated species eg. flora and fauna will be promoted at suitable centres.

The need for assimilation and dissemination of critical data with reference to the mangrove ecosystem is

felt and therefore, the following data bases are identified for further establishment.

A. Bibliographic data base,
B. Mangrove experts data base,
C. Mangrove genetic variability data base,
D. Socio-economic data base,
E. Resources inventory data base, and
F. Audio-visuals data base

At present, MEIS is being developed as two data base, i.e., mangrove bibliographic data base and mangrove experts data base. All these data bases are being developed on the similar concepts of establishing international area network systems and for this, following guidelines will be followed :

1. All the systems will be micro-computer based.

2. Wherever possible, common software packages will be used to facilitate linkages among data bases; it would be seen that these packages are well-known and supported in India and other participating countries.

3. The network will operate on the co-operative information sharing principles.

4. The primary users of this system will be mangrove researchers in all mangrove-rich countries as well as international organisation involved in mangrove research.

5. Products and services which would help sensitive policy makers and the general public will also be produced;

6. To promote and ensure long-term sustainability, both shadow pricing and real pricing of the products and services will be carried out from the beginning. This doesnot imply that

all the revenue must flow into the central source but rather than the participating network members should be able to generate income by distributed common products to their own local users.

7. The system will undergo continue evaluation, based on feedback from the users; and

8. The system will evolve along with simultaneously evolving underlying technology.

5.6.1 Mangrove bibliographic database

This data base is being developed as bibliographic records, each of which describes a bibliographic item (a book, a report, a periodical article, a thesis, etc.). This will be an updated version of "Bibliography on Mangrove Research (1600-1975)", published by UNESCO in 1983 and will initially have around 8000 bibliographic entries.

The information on this data base will be used for information retrieval, for producing printed catalogues, indexes, bibliographies and current awareness bulletins in future. There are two main aspects of this type of data base design ;

1. the structure of the bibliographic record, i.e., the manner in which the information in the record in the fields is divided into fields and subfields, and

2. the content of bibliographic record, i.e. the form of data to be entered in each field.

UNESCO has published the Common Communication Format (CCF), which proposes a common method for structuring bibliographic records, sothat they may be freely exchanged

among different information systems. The software (CDS-ISIS) used by MSSRF for developing bibliographic data base will be useful in a number of ways as it is intended to be used with any microcomputer software designed for data base management, and containing the features required to fulfill the needs of a bibliographic information system. It also has the ability to

- handle relatively long, variable length fields,
- handle relatively large data bases,
- retrieve and sort records using any desired data element, and
- print records in any desired form.

This data base is being indexed using a list of descriptors which is already defined by MSSRF. Abstracts of references are entered in the data base wherever available. They will not be created fresh, but will be entered later. In addition to this, the holdings of the documents listed in the data base would be collected from the member countries of the network. Some additional features of this data base would be :-

1. The overall design of the system will be a decentralised network with each country providing inputs into the MSSRF in machine readable form or on worksheets.

2. Each network member would endeavour to provide copies of documents on request ;

3. Records from previously published bibliography on mangroves will be included in the database to provide a complete updated version,

4. A printed bibliography will be published ; and

5. Copies of the data bases will be made available to participating countries.

Index terms for developing specifications for entering data have already been developed and the work on sorting the references is underway. A standard format for keying in all these references is also being developed. Help is being taken from the Documentation Centre of the National Institute of Oceanography, Goa, for this purpose.

5.6.2 Mangrove Experts Data base

The software CDS/ISIS is also being used with this data base. MSSRF had developed a questionnaire to gather data in this regard and information has already been collected, which is used as the basis for data base design. A printed directory will soon be published.

5.6.3 Mangrove genetic variability data base (gene bank database)

This would be in the form of a catalogue of genetic material (accessions) sorted in the living gene bank collections established as a part of this network.

First, a standardised list of descriptors will be developed, published as in internationally accepted standard and will be used by all members of the network. A descriptor will be nothing but a list of characters which provides passport and biological information for characterising the accession in the gene bank, adequately. Previous experience by other organisations in establishing and documenting gene banks, especially with respect to forest genetic resources, will be utilised. IBPGR could be a valuable source of advice on this point. INIBAP, which has recently designed its own gene bank software will be consulted on a similar survey on software.

This software will initially be based on DBMS package, which is well-known and is used in India.

5.6.4 Socio-economic data base (future)

Surveys of socio-economic information on communities associated with mangroves are being undertaken by MSSRF in India. It is likely that the results of this will be useful to characterise mangrove areas for the resource inventory to be eventually undertaken (see below), as well as for other purposes. Therefore a data base of socio-economic variables may be developed in its own right. Region, coverage, uses etc., would be inputs for this data base.

5.6.5 Mangrove resources inventory data base (future)

In the longer term it is expected that the socio-economic data base will also be linked to a mangrove resources inventory on a country basis (see below). Ideally these inventories will be merged to provide a global perspective. Geographic Information Systems (GIS) software will be used as a basis for this inventory. Remote sensing techniques can provide much of this data using modern analysis methods.

In addition to physcial data, the data base would include socio-economic and mangrove usage information perhaps extracted from or linked to the socio economic data base as previously mentioned. Each area will also be characterised by relevant biological variables including descriptors from the gene bank data base.

5.6.6 Audio-visuals data base (future)

MSSRF will be producing and collecting various A/V materials related to mangrove ecosystems. In the future it may

be useful to enter references to these in the data base and perhaps to enter some of these materials in digital form as well. Obviously multi-media technology could be considered as a vehicle for delivering this information.

An international Advisory Committee has already been formed in January 1992, under the Chairmanship of Dr. Robert Valentin from IDRC, which gave detailed guidelines for development of data bases. The other members of the committee are: Prof. B.R.Murty, Prof. V. Arunachalam (IARI, New Delhi), Dr. Barry Clough (AIMS, Australia), Prof. Roland Mollby (Karolinska Institute, Sweden). They have offered detailed advice on statistical and programming aspects.

5. UTILISATION

UTILISATION

6.1 Introduction

In Asia and Pacific region, nations have managed their mangrove forests on a sustained yield basis. They have considered the production and sustenance of maximum volume of wood for domestic and export purposes, ecological protection and conservation, preservation of initial coastal mangrove habitat and the provision for livelihood and employment opportunities to mangrove-dependent communities. In case of India, the population pressure in the coastal areas has been more as compared to other countries. Therefore, a multiple-use concept has to be introduced for utilisation of mangrove ecosystems which would mean the management and utilisation of various renewable resources found there so that these would best contribute to the long-term socio-economic development of the country. This will also lead to long-term benefits to the greatest number of people.

6.2 Socio-Economic survey

Socio-economic activities in the vicinity of mangrove habitats like Pichavaram are very much varied. Poverty seems to have settled together with unwise resource utilisation. The people living within and nearby the mangrove forests depend on this resource for their living. The immediate material benefits they are deriving from these resources and lack of knowledge and understanding on the other mangrove influences, have hindered them from realising the more significant and long-term benefits of this ecosystem. It was therefore decided to understand the behaviour of local people residing within and around Pichavarm mangrove forest, before understanding their occupational impacts on the coastal ecosystems.

Mangrove ecosystem of Pichavaram provides enormous goods and services which are vital to the well being of the local population. These goods and services range from tangibles as those directly consumed (food, medicine, firewood), trades in market (fishes, prawns, etc.), and non-consumptive services (protection against wind breaks) to more intangible values of knowing that species exist and should continue to exist and also that they are to be conserved and protected for the future. However due to economic requirements, people in many coastal areas have over-exploited the mangrove forests. On the other hand, disturbed areas experience temporary or permanent disruptions of water supplies, increased flooding, reduction of water quality and productive decline in faunal species.

6.2.1 General information on the villages

The area occupied by the villages/hamlets, including Pichavaram and Killai is 15. 36 sq. km. Under the Chidambaram taluk, Pichavaram is divided into north Pichavaram, South Pichavaram and Elanthaimodu which in turn are divided into many hamlets. According to the sources from Killai Town Panchayat Office, there are about 15 hamlets in all which includes hamlets around Pichavaram and the revenue villages namely, Killai and C.Manambadi. The 1981 census shows a population of 9303. There are 7 Panchayat union schools, 1 Govt. high school and Harijan welfare school and about 9 rural feeding centres. 53 hand pumps, 20 open wells and 8 ring wells are the only source of water with only one pump house.

There are 3 daily markets.

Hamlets with farming as main occupation	Fishing hamlets
Ponnanthittu	Chinnavaikkal
Manambadi	Kannagi Nagar
Singarakuppam	Killai Fishermen Colony
Thaikkal	Muzukkuthurai
Killai Thirunalthoppu	Mudasalodai
Kuchipalayam	Nadumudasal
Tandavaransozhanpettai	Palazhayar
	MGR thittu

A preliminary socio-economic survey, initiated in the villages from October 1991, was conducted in 7 hamlets out of which 4 were fishing hamlets namely Chinnavaikkal, Kannagi Nagar, Muzhukkuthurai and Killai Fishermen Colony, and 3 with farming as main occupation namely, Killai, Thaikkal and Singarakuppa. Few Government employees were also surveyed. A questionnaire was prepared for this purpose and based on the responses obtained from these hamlets each time, it was modified. Household was considered as basic unit of analysis.

The main objective for undertaking this kind of survey was to see the percentage of total population dependent on mangroves and to assess the requirements of the local communities (energy, fuel, food, etc.).

It also helped to understand (a) what kind of products are being extracted from the mangroves, (b) social and economic benefits derived, (c) compatibility of the resources in use, and (d) what intangible mangrove services may be lost if the exploitation continues.

To support this study, the following data was collected:

- Population structure,
- Occupational details,

- Traditional utility and commercial exploitation of some mangrove products,
- Techniques adopted in the collection of resources, and
- Impact of human induced disturbances on mangrove ecosystem.

Secondary data collection was also done with the help of information gathered from Chidambaram Taluk, Killai Panchayat Office, and the heads of the villages or hamlets.

The questionnaires provided information about family structure, particulars of the dwelling units, educational levels and occupational details. Observations based on these surveys are categorised and discussed under the following heads:

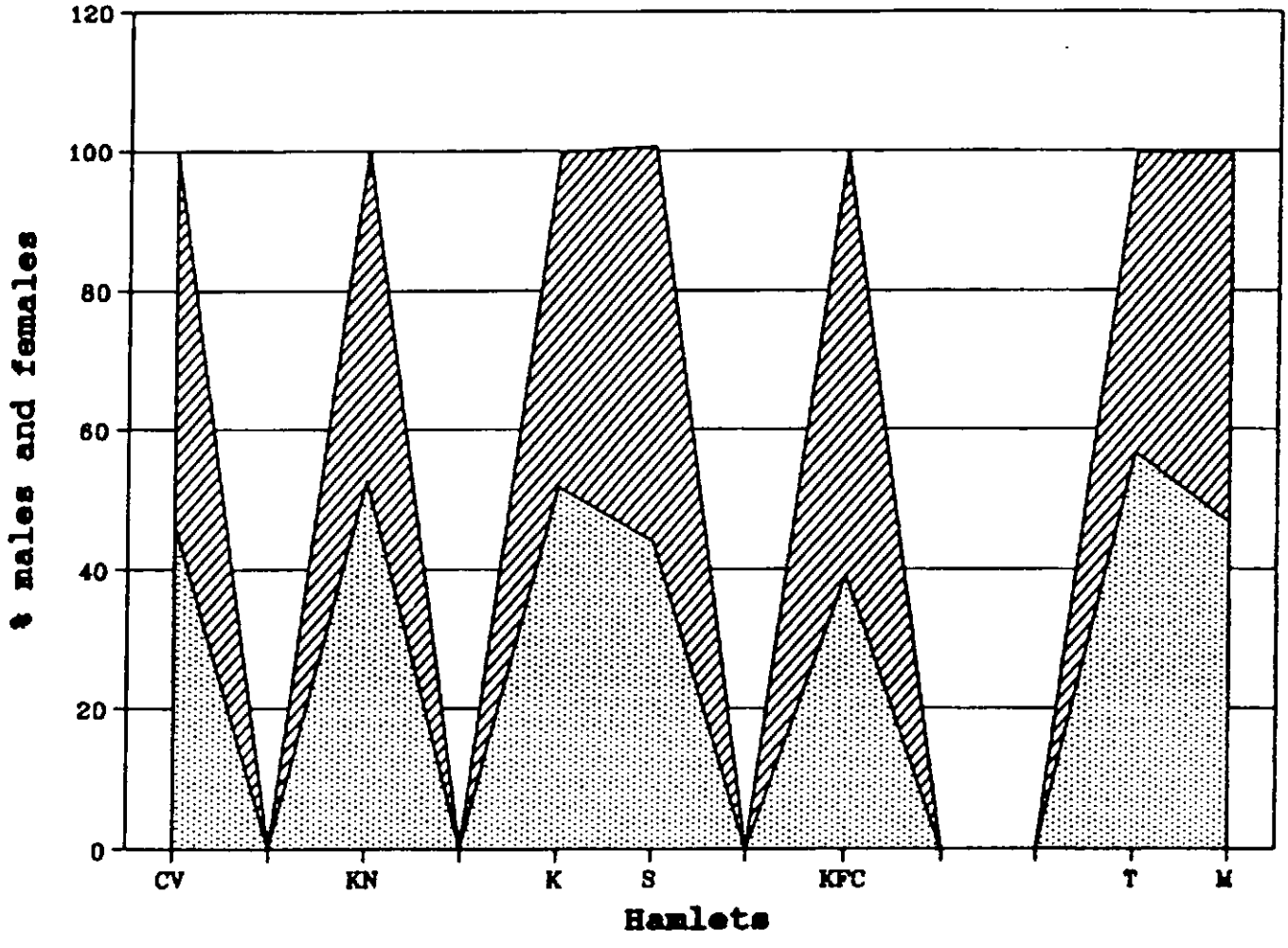
6.3 Socio-demographic Profile

The household head or the primary income earner, which was considered as the unit of analysis for the socio-demographic profile was found to be very closely related to the socio-economic condition of the household. The profile of these hamlets is highlighted with the help of Figures 6,7 and 8.

6.3.1 Education

In almost all the hamlets surveyed, it was seen that the majority of population attended Primary and Secondary schools (Figures 9 and 10). Only a few attended higher secondary school and none of them went for any course or diploma. In particular case one of the respondent was an engineer. Generally, children - especially boys were observed attending school not beyond 9th or 10th standard and helped the family in fishing or farming activities.

Figure 6 : Average population of the hamlets surveyed



CV - Chinnavaikkal
KN - Kannagi nagar
K - Killai
S - Singarakuppam
KFC - Killai fishermen colony
T - Thaikkal
M - Muzukkuthurai

Figure 8 : Age structure
(Farming community)

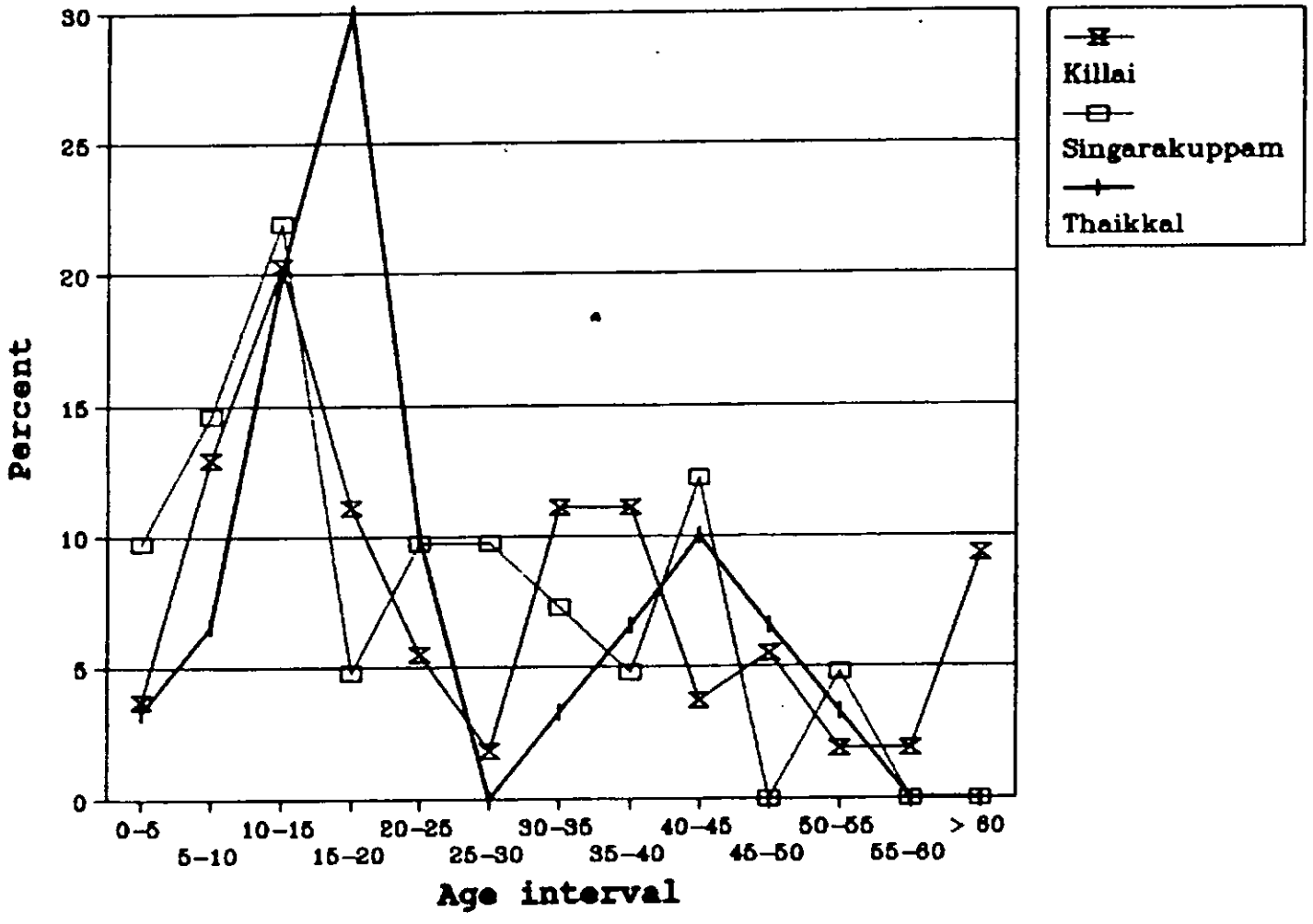


Figure 9 : Education
(Fishing community)

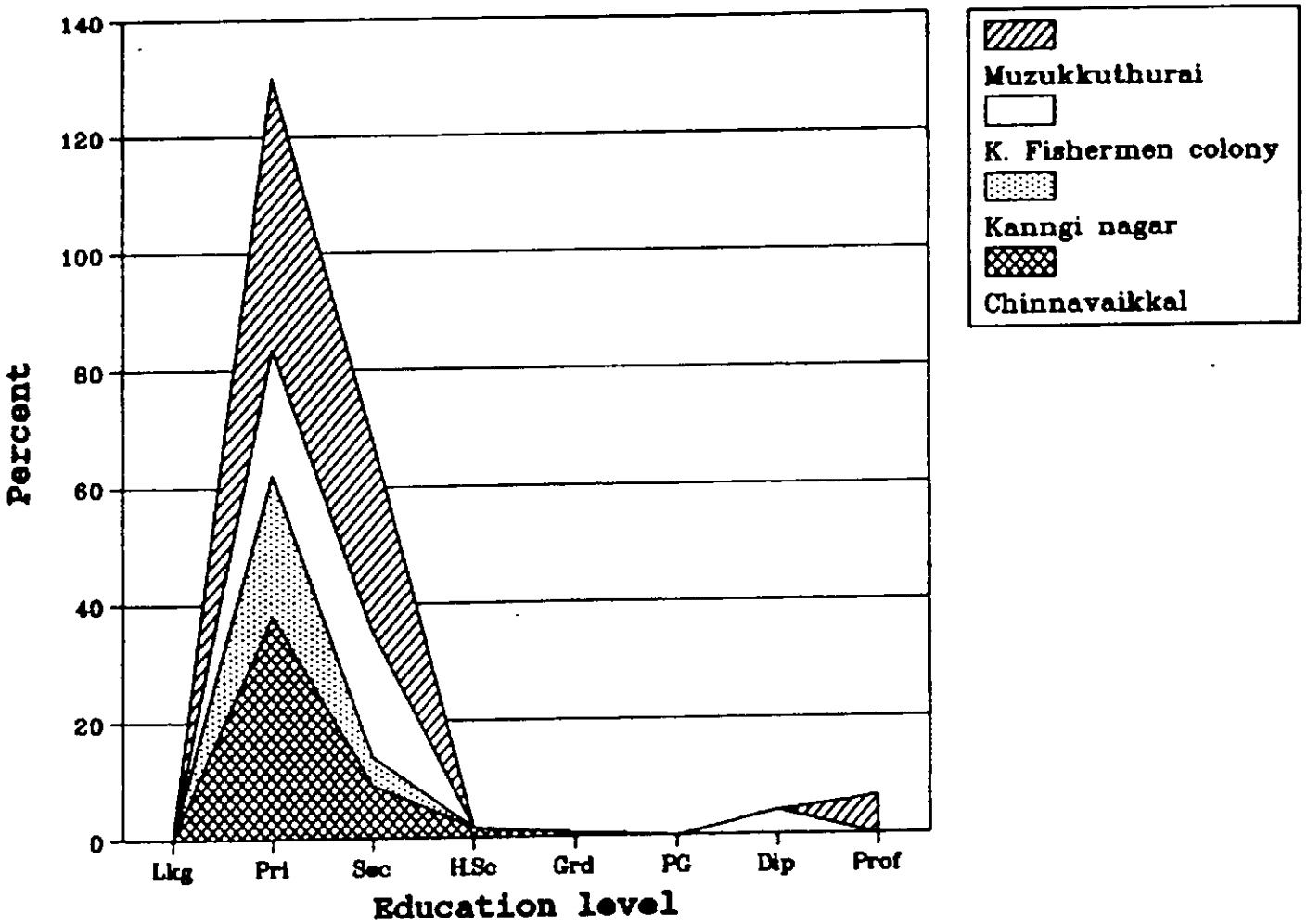
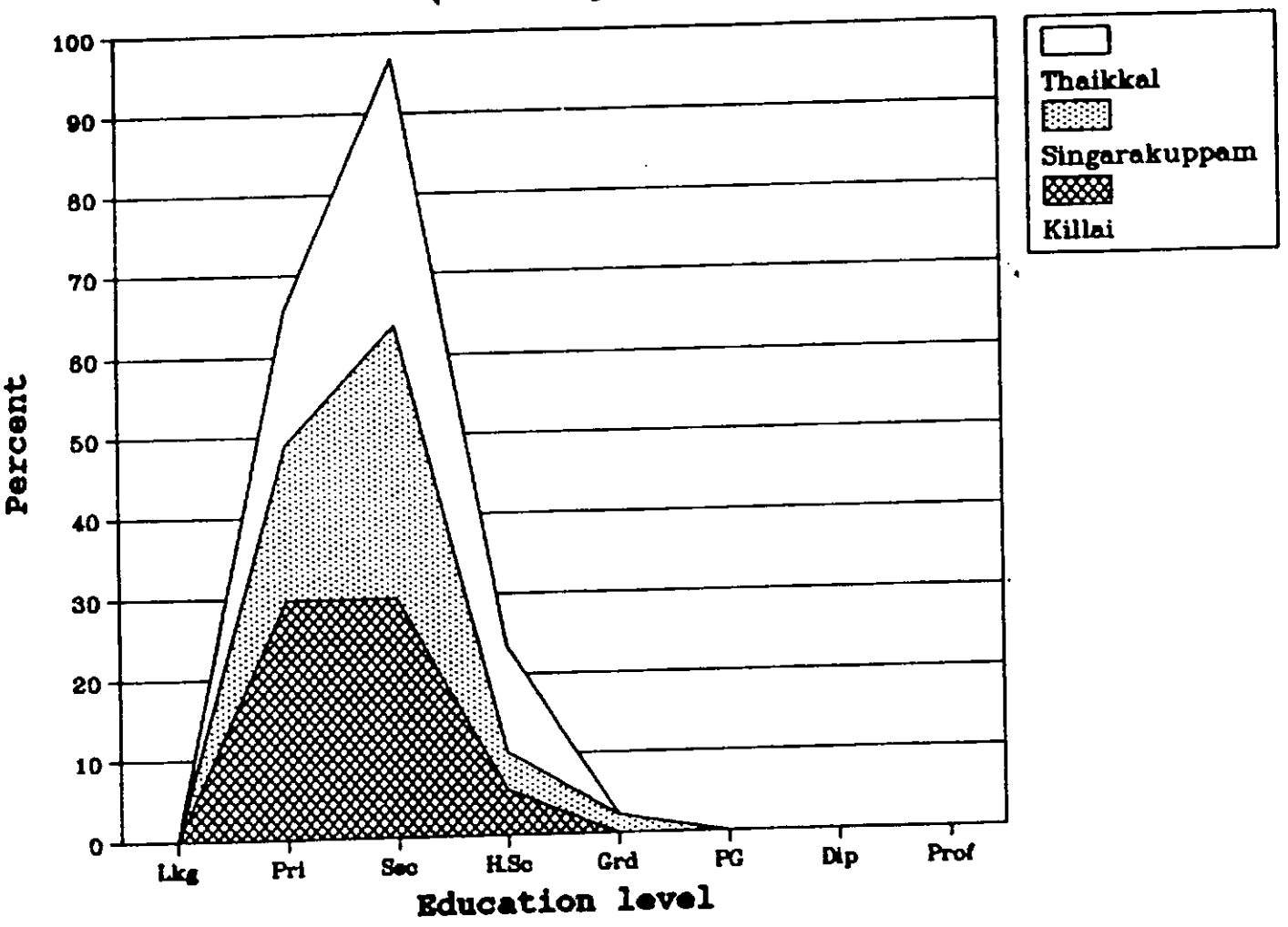


Figure 10 : Education
(Farming community)



6.3.2 Occupation structure

For the purpose of investigating the percentage of population dependent resources from mangrove environment livelihood security, villagers were categorised mainly into classes dependent on mangrove environment either directly or indirectly, and those that are independent of the resource.

Fishing and farming were observed to be the main occupation of the people from 8 and 7 hamlets, respectively. A small percentage of the population was small businessmen (tea shop owner, tailor, etc.) or Government employees. The fishing population was found to have supplementary occupation during the non-fishing season.

6.3.3 Income and income distribution

The average monthly income was found to have ranged from Rs.350 to Rs. 1031. The income generation was found to be quite low in most of the hamlets. Fishermen took up supplementary occupations usually during non-fishing season, and even during fishing season, indicating low profits in the family. Low income generation was observed in spite of increase in number of working members. Though in both the fishing and farming populations, father was the primary source of income, only farming population showed a higher percentage of mother and offspring being additional source of income (see Figures 11 and 12). Average monthly income of different hamlets is shown in Table 11.

TABLE 11: AVERAGE MONTHLY INCOME OF FAMILIES SURVEYED WITHIN AND NEARBY PICHAVARAM FOREST

Hamlet	Income/month (in Rs.)
Fishing	
Chinnavaikkal	500
Kannagi Nagar	593
Killai fishermen colony	730
Muzukkuthurai	967

Figure 11 : Primary source of income
(Fishing community)

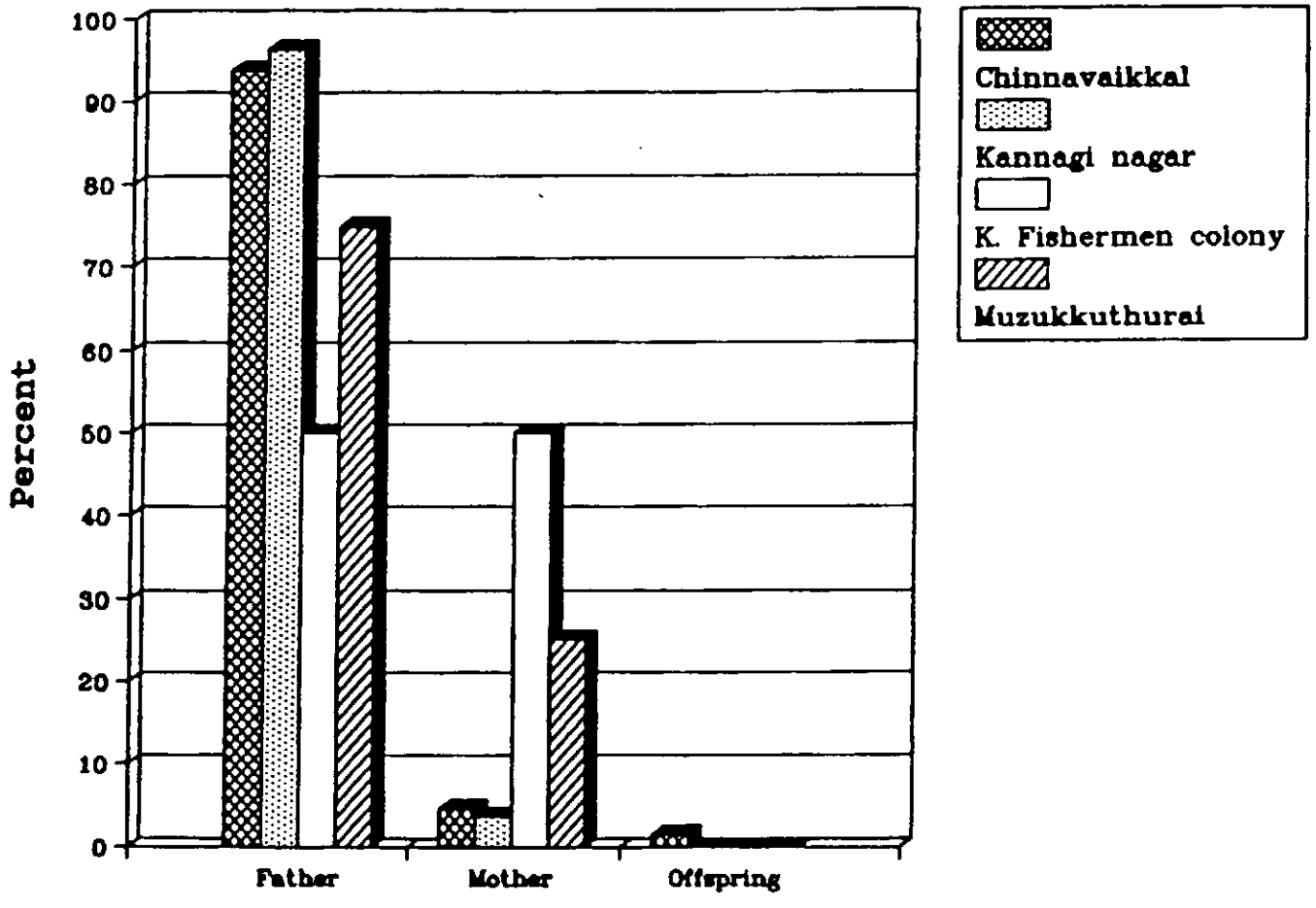
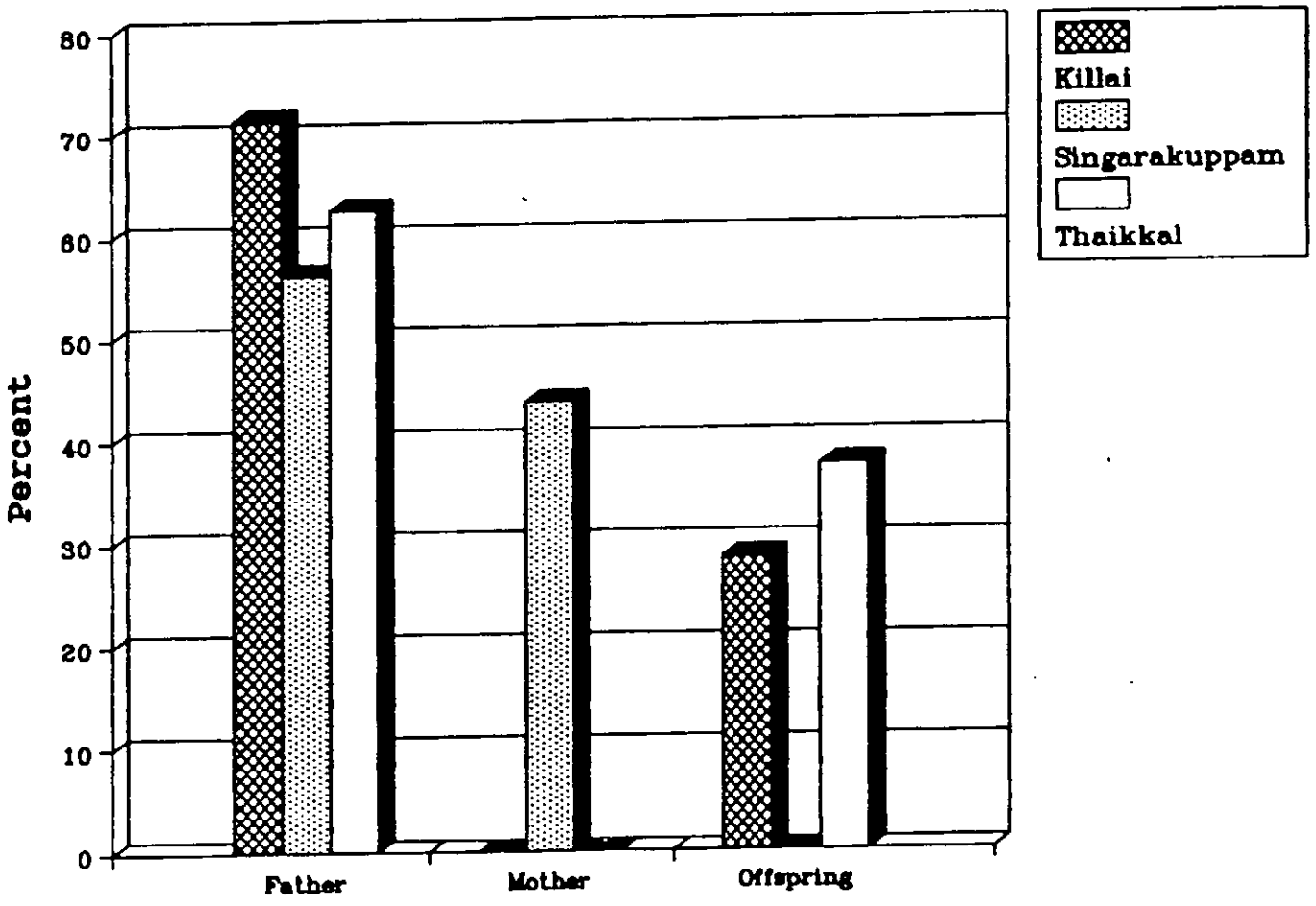


Figure 12 : Primary source of income
(Farming community)



Hamlet	Income/month (in Rs.)
Farming	
Killai	1031
Thaikkalm	350
Singarakuppam	598

The average yearly expenditure or domestic budget was found to be more in the farming population and less in the fishing population.

6.3.4 Standard of living

This depends largely on its disposable income relative to its size as well as on the availability of public services and social amenities. Taxes associated with the communities under study are very insignificant and the net income was considered as the disposable income of a household.

6.3.5 Fishing Community

In the fishing hamlets, the houses are only thatched. The walls are made of mud and the roof is built with palm leaves or coconut leaves. Some had their own houses in Killai, made up of tiled roof and brick walls. The size of rooms ranged between 5 x 5 ft to 30 x 20 ft. Some also owned lands ranging from a minimum of 3 cents to a maximum of 2 acres. The fishermen sold their daily catch for livelihood. About 80.2% of the population owned boats and 88.0% nets. During the peak fishing season (January to June), the fishermen made temporary dwellings close to the sea or water for trapping fishes. During the peak season, less time was spent for fishing and more time in entertainment. The average catch in the peak season was observed to be 5-10 kg per day which reduced to 1/2 to 1 kg or sometimes nil during off-season. About one fourth of the catch was sold and the rest used by the family. The catch

included fish, prawns and crabs and the price ranged from Rs. 25 upto 100 per kg in different seasons, depending upon the size of the species caught.

In the hamlets with farming as main occupation, the houses were built using tiles and bricks with the room sizes ranging from a minimum of 5 x 5 ft to a maximum of 50 x 15 ft. Minimum size of land holding was found to be 2.5 cents and maximum 25 cents. The major crops were paddy (types - IR 50, IR 38, ADT 38, CO 43) and groundnut. The average yield of paddy was observed to be within a range of 13 to 24 tonnes per acre. Casuarina plantations were raised to meet firewood demands. The major farming activity was observed during January and March and then from August to November. Among all the three hamlets with farming communities surveyed, only 21.4% of the population were agricultural land owners while the rest of the percentage denoted agricultural labourers. Number of working days/month for labourers ranged from 25 in busy season to 12-15 days in off-season. Their earnings/day ranged from Rs. 25 for males and Rs. 16 for females. Table 12 comprises standard or indicators of living.

TABLE 12: STANDARD OR INDICATORS OF LIVING

	Hamlets with fishing Communities				Hamlets with farming Communities		
	CV	KN	KFC	MUZ	K	S	T
Room size: (ft)							
Min	4x8	8x6	10x12	5x5	8x6	5x7	5x5
Max	30x20	20x10	20x12	30x20	50x15	22x10	15x10
Land size: (cents)							
Min	3	3	-	4	2	2.5 - 5.5	4
Max	2	1	-	30x20	20x12	25x02	25
Domestic budget per year							
Average	6000				14000		

CV - Chinnavaikkal
KN - Kannagi Nagar
KFC - Killai Fishermen Colony
MUZ - Muzukkuthurai
K - Killai
S - Singarakuppam
T - Thaikkal

6.3.6 Energy Consumption

Firewood was found to be in maximum use when compared to other sources of fuel. Since electricity facility was not available in most hamlets, kerosene was used for burning the lamps. Biomass, alongwith dung was observed to be used as energy consumption.

The average requirement of firewood for a family was found to be 1 "gundu" (1 "gundu" = 25 Kg) the cost of which is Rs.15-20. About 3-5 litres (cost - Rs.3 or 2.50/litre) of kerosene was required per month if used for lighting purpose alone. Excepting Killai and Thaikkal, the electricity facility in the other hamlets surveyed was very low.

TABLE 13: ENERGY CONSUMPTION PATTERN (%) IN HAMLETS SURVEYED

Hamlets	Firewood	Kerosene	Electricity	Biomass
Killai	94.4	88.0	76.0	11.7
Thaikkal	80.0	75.0	73.0	20.0
Singarakuppam	74.0	82.0	30.0	30.0
Chinnavaikkal	99.3	42.0	11.3	64.0
Kannagi Nagar	90.0	51.8	8.5	52.0
Killai Fishermen Colony	86.6	36.5	18.2	51.0
Muzukkuthurai	79.0	33.4	9.1	44.0

6.4 Uses of Mangroves

Mangroves of Pichavaram offer a wide range of multifarious benefits. However, human activities and interventions within and near mangrove areas are leading to their degradation. In Pichavaram, firewood from mangroves is commonly used for cooking. Rhizophora and Avicennia are the most commonly used species as they have very high calorific value and emission of very little smoke. Stilt roots of Rhizophora are also used as roof material whereas branches of

Avicennia are used as fencing material; and also as fishing poles. Mangrove forests also serve as resource for other faunal elements such as source for fish and prawns. Oysters clinging on stilt roots of Rhizophora are gathered by poachers which are used as an ingredient for making whitewash for buildings. Mangrove stilt roots are also examined for their use as mosquito repellents by nearby research institutions and are thus are utilised as source of medicine.

6.5 Sustainable Livelihood Security Index (SLSI)

Efforts were initiated to apply the concept of SLSI in the Pitchavaram area with the following aims.

1. to outline the pathway to sustainable development of our coastal ecosystems with special reference to mangrove ecosystem,

2. to discuss the economic issues involved in the utilisation of mangrove resources,

3. to develop a mathematical framework useful to capture and analytically show the ecological-economic-equity interactions in the context of mangrove ecosystems, and

4. to indicate certain policy options and action plans essential for the sustainable management of mangrove ecosystem.

Human and mangrove interaction has been evident from the studies undertaken, and it is observed that the local people, most frequently act with seeming disregard for the future ecological effects of their action, of exploitation of mangrove resources. It is apparently due to sheer survival instinct for the simple reason that no feasible alternative occupation exists for their well-being. Therefore, a community-based approach needs to be brought about for

restricting over-exploitation of mangrove forest. At the same time, a detailed analysis of social behaviour of such people is vital before any concerted attack on their profession can be made with any hope of success. Development of a livelihood security index would prove to be one of the pioneering efforts in this field.

6. EDUCATION

EDUCATION

7.1 Introduction

Not every community in the country is endowed with mangroves and swamp lands. However, the areas with mangrove ecosystems are always under stress as the resources are always used by the local population for their livelihood security. For example, the bulk of mangrove resources has been used for firewood, a marginal livelihood activity. In this context, the population residing in the vicinity of such mangrove areas needs to be made aware of how mangroves are important and why they should be conserved. Moreover, it becomes imperative to encourage the local government to focus attention on these mangroves resources in their respective territories.

The major objective of this programme is to create awareness for the conservation of this neglected ecosystem, fragments of which are found scattered in variously degraded forms in and around Pichavaram mangrove forest. The work will include preparation of visuals based on interesting features of the ecological importance of the mangrove swamp areas from India in general and Pichavaram mangrove forest in particular. Communication methods used will be display of posters and charts, slides and transparencies and also arranging lectures and discussions. Target groups benefited by this activity will be primarily the people living along the coastal villages and also administrators and decision makers.

The information collected will also be conveyed to the students, teachers and researchers in colleges and universities in coastal states.